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Original Article

# FIELD AND ECONOMIC STUDIES OF TRACTOR OPERATED MANURE SPREADER WITH REAR VERTICAL ROLLERS- A NEED BASED STUDY FOR ORGANIC FARMING APPROACH IN INDIAN AGRICULTURE

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***ABSTRACT***

***In India, farmers are still following the traditional method i.e. a loaded trolley is moved in the field and stopped at regular intervals to unload a small amount of manure in the form of heap and the heaps are later spread manually. This traditional method results in uneven spreading and undefined rate of application. Mechanized application of farm yard manure is very important to boost the concept of organic farming. But no mechanical means are available for spreading farm yard manure in India. In order to mechanize this operation a tractor operated solid manure spreader with rear vertical rollers was evaluated in the field. The moisture content of manure used for the operation varied from 30-40 % (w.b.) and its density varied from 430-480 kg/m$^3$. The machine loading capacity varied from 1.0-1.2 tonnes. The machine was operated at different forward speeds between 2.0 to 7.0 km.h$^{-1}$ and at 1400, 1500 and 1600 engine rpm. The machine mean swath width varied from 2.3-4.0 m, mean field capacity varied from 0.11 to 0.55 ha.h$^{-1}$ and mean fuel consumption varied from 5.35-7.80 l.h$^{-1}$. The manure mean application rate during field experiments varied between 10.58-36.37 t.ha$^{-1}$. The average saving in time for spreading manure with tractor operated manure spreader was 66.17 % and average saving of cost was 50.43 % as compared to traditional trolley method. Increasing of engine rpm and forward speed of tractor combinedly resulted in increase in field capacity of machine, increase in fuel consumption and decrease in manure application rate per unit area. The farm yard manure spreader can be a boon for organic farming and also it can provide a good employment opportunity for rural youth as this machine can be successfully run on custom hiring basis.***

***KEYWORDS:*** ***Farm Yard Manure, Rear Roller, Manure Spreader, Engine RPM, Fuel Consumption***

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## INTRODUCTION

Mostly, solid manure is spread using broadcasting equipment or traditional method followed by tillage to incorporate the manure into the soil. Delayed incorporation can result in increased odour, risk of nutrient loss in runoff and volatilization losses of manure nitrogen. The problem faced during manure spreading is not only in matter of its application rate but also its uniformity of spread. Farmyard manure is considered as the eco-friendly bio-fertilizer for the highly polluted modern era. The farmyard manure application is a basic input operation in crop production. The application system includes equipment for loading of manure at storage facilities, transporting to the application sites and applying the proper quantity of manure uniformly to soil-crop systems. Proper application of manure to the land is essential to prevent pollution of land, ground and surface water and to prevent loss of ammonia and other nutrients from the manure. Timely application of manure in accordance with the nutrient requirements of the crops resulted in improved crop production. It is important that while spreading

the manure in the field, the quantity of manure should be balanced with the nutrient requirement of the crop. The manure should be covered with soil (e.g. harrowing) immediately after spreading or should be injected into the soil directly. Well rotten FYM contains 40-50 % moisture. Millions of tonnes of organic solid waste are produced every year in India and the land application of these solid wastes has become a popular method of disposing them in an environmentally safe manner. Spreading the manure in the field is laborious, tedious and there is no mechanical device commercially available in India to spread the solid organic manure uniformly in the field. Glancey and Adams (1996) evaluated an applicator for topdressing (or side dressing) row crops with solid waste materials. The apparatus can meter and deliver animal manures and other raw solid waste materials between rows of a growing crop without the material contacting the crop. Results from a 3-year field study clearly indicate that new poultry litter management strategies, using this litter topdressing equipment and improved soil and plant nitrogen tests, should improve the agronomic and environmental efficiency of maize production in the mid-Atlantic region of the USA. Economically optimum yields were obtained with starter fertilizers and moderate topdress nitrogen rates, and poultry litter as a topdress material was found to be as effective as topdressing with a commercial fertilizer. Comparison of total application costs revealed that topdressing with poultry litter was about US $10 per ha more expensive than conventional methods, which can be attributed to the lower concentrations of nitrogen in poultry litter, requiring significantly more applications and greater operator time per hectare. Davis and Meyer (1998) designed a new trailer manure spreader. This manure spreader could be quickly converted to capacious trailer. It had 4 tonne capacity with a body 10 ft long by 6 ft wide and sides approximately 2.5 fthigh. It spread finely for it was designed primarily as a power driven spreader. The rotor runs at a peripheral speed exceeding 2000 ft per min. to deliver over 25,000 cuts of load per minute. Ling and Wilhoit (1999) evaluated the power requirements for the spinner type spreaders for broad-casting solid waste. The spinner power was evaluated by measuring the hydraulic pressure drop across the two spinner motors while the conveyor power was calculated based on formula developed for a typical spinner type spreader. The maximum power requirements for spreading poultry litter andash at a material flow rate of l.52 $m^2$/min. and spinner speed of 830 rpm was close to 19kW. Landry et al (2002) worked to optimize the design and operation of solid and semi solid manure handling and land application equipment. The specific objective of the work report was to apply the distinct element method (DEM) to the study of the solid and semi solid manure physical and flow properties and machine manure interaction in handling and land application equipment. Earlier the manure products models were developed using models of the test equipment used to measure manure physical and flow properties. Machinery manure interactions were then studied using DEM models based on product property. The modeling approach and the preliminary models were presented. The research was very significant in gaining and enhanced understanding of the dynamic behavior of solid and semi solid manure in handling and land application equipment that will allow for the optimization of the design and operation of such equipment. Landry *et al* (2005) studied the performances of different conveying systems for manure spreader and studied the effect of the hopper geometry on material flow. The prototype land applicator was evaluated with both a scraped conveyer and a system of four-auger. The specific energy required to unload the machine with the four auger system was found to be higher than with the scraper conveyor, with average value of 184 and 73J/kg respectively. A three factor factorial was used to study the effect of the vertical position of flow-control gate, velocity of the conveying system and inclination angle of the side walls for both type of conveying systems. The specific energy for both conveying system was significantly affected by the position of the gate. The characteristics flow rate, as defined in European Standard EN 13080, influenced by all three factors in the case of scraper conveyor. The position of the gate, velocity of conveyor and the interactions between these two factors were found to be significantly affecting the characteristics flow rate of the four-auger system. The output flow of three commercial manure spreaders having similar functional units but different hopper

geometry was studied. The stretch within the tolerance zone was observed to increase when the length and the width of the hopper were increased. The longitudinal coefficient of variation was observed to decrease when the length of the hopper was increased. The same effect was observed when increasing the width of the hopper and when reducing its depth. The physical properties of the products spread were deemed to have an influence on the response of the evaluation criteria to changes in hopper geometry. Cohesive products were observed to improve the discharge flow in terms of the stretch within the tolerance zone, the longitudinal coefficient variation and the actual to theoretical unloading time ratio. Now, there were many improvements in these machines by making arrangements for special attachments. End gate provided for manure could be raised or lowered by operator seat for spreading line or hilling concentrated manure such as dry chicken on pulverized sheep manure, some models were equipped with brakes and scraper also. Sapkale et al (2010) evaluated a tractor operated manure spreader. A manure spreader was attached to the 45 HP tractors through the hitch point. The PTO rpm of 540 was used to operate the rotary blades of manure spreader. The distribution pattern of farm yard manure was uniformly spread over the area and little variation was found. This was due to presence of clods in manure. The actual average swath width of manure spreader was found 7.6 m but the effective swath was taken as 7.4 m by considering the overlap, uniformity of application and spread pattern. The manure spreader was operated in two different fields. The theoretical field capacity of a tractor operated manure spreader was found to be 1.95 and 2.06 and average actual field capacity of the tractor operated manure spreader was found to be 1.39 and 1.47 at forward speed of 2.44 km/h. The average field efficiency of the tractor operated manure spreader was found to be 71.55 per cent. The field application rate of farm yard manure was observed to be 5.44 and 5.89 t/ha. The cost of spreading with the tractor operated manure spreader was Rs. 247 per ha. The saving in cost and time were 72 and 94 per cent, respectively as compared to conventional method. Shen *et al* (2011) evaluated the tractor drawn manure spreader. The investigation was done to know the causes for differences in compost application rate in a field using two types of manure spreaders and clarified it by measuring the travel tracks of the manure spreaders using a RTK-GPS system. The travel speed of each application pass was not constant, and the variation ranged from 0.9-1.6 m/s. The standard deviation of an individual track distance did not significantly change. However, there was a maximum change of 2.5 m between each track distance in the test field. The results show the differences in compost application rate are due to the changes in travel speeds and track distances. Singh and Singh (2013) developed a tractor trailer-cum-farmyard manure spreader having two tonne capacity. The machine consisted of two wheeled tractor-trailer, trapezoidal shaped manure box, sheet sliding mechanism to control the manure delivery rate, feeding auger and manure spreader unit. The machine was tested in the field by using a 35 hp tractor at forward speeds of 0.41 to 1.12 m/s with the farmyard manure of average bulk density of 400 kg/m$^3$and moisture content 28%. During field testing, manure application rate ranged from 2.0 to 36 t/ha. The machine worked satisfactorily and achieved uniform application of farmyard manure in the field and reduced human drudgery significantly as compared to manual spreading of piled manure in the field. The field capacity of machine ranged from 0.23 to 0.58 ha/h at forward speed of 0.41 to 1.12m/s.

From the above cited literature it is clear that a considerable amount of work has been done in improving design and performance of farmyard manure spreader but considerable work needs to be done on this machine in India, keeping various factors in account i.e. manure moisture content, machine capacity, effect of machine parameters on field capacity and uniformity of manure spreading. Therefore, the present study was conducted to evaluate the performance of tractor operated farmyard manure spreader and also to compare its performance with traditional trolley method.

## MATERIALS AND METHODS

The manure spreader machine make was Agricola Italiana (F.lli.Annovi, Imported from Italy). The specifications of manure spreader are shown in table 1. Its capacity varied between 1.0-1.2 tonne depending upon moisture content of the farmyard manure. It is shown in Figure 1.

**Table 1: Specifications of Manure Spreader**

| S. No. | Specifications of Manure Spreader | |
|---|---|---|
| 1 | Overall dimensions, mm | 5000 x 1600 x 1450 |
| 2 | Overall dimensions of tub (L x B x H), mm | 3000 x 1100 x 600 |
| 3 | Capacity of tub, $m^3$ | 2.0 |
| 4 | Tyres Size | 10.0/75 - 15.3 |
| 5 | Overall Weight, kg | 800 |
| 6 | Number of vertical rollers | 2 |
| 7 | Spacing between vertical rollers, mm | 600 |
| 8 | Spacing between tub base and roller base, mm | 300 |
| 9 | Speed ratio between PTO and rear rollers | 1:1 |

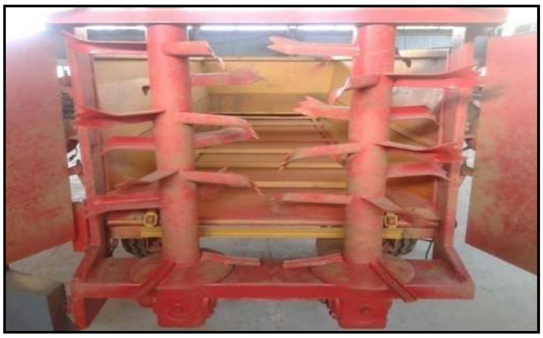

**Figure 1: Stationary View of Tractor Operated Solid Manure**


**Figure 2: View of Rear Rollers and Chain Conveyor**

It has two mechanisms viz chain conveyer and two vertical rollers with 110 mm shaft diameter (Figure 2). Both are driven through tractor PTO. Chain conveyer mechanism (Figure 2) imparts movement to the farmyard manure towards rear side. There is provision for varying its speed given on side of trolley. The height of vertical rollers is 870 mm and 12 no. of beaters are attached in staggered pattern to each roller for spreading the manure. The length of each beater measured was 250 mm. The rear vertical rollers move in opposite direction. This movement spreads farmyard manure uniformly behind the trolley. This movement also breaks the bigger clods. The peripheral speed of vertical rollers can be varied by increasing/decreasing the tractor engine rpm. During field testing 55 HP tractor was used. The specifications of the tractor used for the present study are given in Table 2.

**Table 2: Specifications of the Tractor**

| Specifications of the Tractor | |
|---|---|
| Type | DI, 4 Stroke, Diesel |
| Steering | Power Steering |
| No. of cylinders | 3 |
| Horse Power | 55 HP |
| Rated RPM | 2200 |
| Transmission | Fully constant mesh gear box |
| Drive | 2 WD |
| No. of gears | 8F+2R |
| Maximum Forawrd Speed | 39 Kmph |
| PTO HP | 52 HP |
| No. of splines | 6 |
| PTO rpm | 540@1600 Erpm |

**Figure 3: Tractor Operated Solid Manure Spreader with rear Vertical Rollers during Field Operation**

The drive from PTO shaft has been given to rear vertical rollers through main shaft below manure spreader body. This power was differentiated between two vertical rollers with the help of gearboxes provided below each vertical roller. Then from one of these gearboxes drive has been given to chain conveyer system through cam follower mechanism. Also for safety during transportation mode provision of light as well as safety emblem has been installed at rear side. Two rear doors (770 x 500 mm) were provided to regulate the spreading width. The tractor operated solid manure spreader was filled with farmyard manure upto its full capacity for each experiment. The moisture content of the farm yard manure used for present study varied from 30-40 % (w.b.) and its density varied from 430-480 kg/m$^3$. The experiment was conducted at different forward speed and engine rpm combinations. Though the manure tub was filled with 1.2 tonnes of manure for each experiment to avoid variation in data. Tractor was operated at forward speeds varying from 2.0-7.0 km/h and at 1400, 1500 and 1600 engine rpm (Figure 5). The parameters recorded were forward speed, fuel consumption, effective swath width and manure application rate.

## RESULTS AND DISCUSSIONS

The capacity of tractor operated rear roller manure spreader varies with the moisture content of farmyard manure. Therefore, its capacity is directly linked with the moisture content of farmyard manure. The tractor operated manure spreader was operated in the field at different engine speed and forward speed combinations and data recorded are shown in Table 2 and Table 3. At first low gear i.e. when the manure spreader was operated at speeds below 2.0 kmph the spreading was not found to be uniform i.e. the performance of manure spreader was not satisfactorily. At speeds below 2.0

kmph it was merely making heaps of manure instead of spreading it properly. Therefore the experiments were conducted for speeds above 2.0 Kmph i.e. for 2nd, 3rd and 4th low gears. By changing the gear the forward speeds were varied and three levels of forward speeds were achieved at each gear by changing the engine rpm. At speed more than 7.0 Kmph the spreading was again not uniform and operator performance was also affected during turning. Therefore, experiments were conducted between forward speeds varying from 2.00-7.0 kmph. As it is clear from Table 1 that Gear levels were 2nd, 3rd and 4th low and engine rpm levels were 1400, 1500 & 1600. During field experiments the forward speed varied between 2.0-7.0 kmph. It is clear from Table 3 that as the engine rpm increased, the peripheral speed of the rear vertical roller also increased which resulted in increase in swath width of manure being spreaded thereby increasing the effective field capacity of the machine. The effect of engine rpm was significant ($p<0.05$) on the swath width. Manure swath width varied from 2.3-4.0 m for different gear and engine rpm combinations.

Effective field capacity of the machine varied from 0.11-0.55 ha/h during field experiments and increased with increase in forward speed and engine rpm. Thus effective area over which the manure was spreaded also increased resulting in decrease in manure application rate per unit area. The effect of gear and engine rpm individually and in combination was significant ($p<0.05$) on the effective field capacity of the machine. As the tractor forward speed and engine rpm were increased fuel consumption also increased and fuel consumption varied from 5.35-7.80 l/h during field experiments. The effect of gear and engine rpm individually and in combination was significant ($p<0.05$) on the fuel consumption.

**Table 3: Effect of Engine Rpm and Forward Speed on Swath width, Fuel Consumption & Effective Field Capacity**

| **Gear** | **Engine Rpm** | **Forward Speed Kmph** | **Swath Width, m** | **Fuel Consmp. $l.h^{-1}$** | **Effective Field Capacity $ha.h^{-1}$** | **Manure Application Rate $t.ha^{-1}$** |
|---|---|---|---|---|---|---|
| **(1)** | **(2)** | **(3)** | **(4)** | **(5)** | **(6) = (3) x (4) x F.E.*/10** | **(7)** |
| | | | **Mean+S.E.** | **Mean± S.E.** | **Mean±S.E.** | **Mean±S.E.** |
| L2 (2nd low) | 1400 | 2.45 | 2.3 ± 0.03 | 5.35 ± 0.02 | 0.11 ± 0.00 | 36.37 ± 0.42 |
| | 1500 | 2.52 | 2.4 ± 0.03 | 5.50 ± 0.02 | 0.12 ± 0.00 | 32.10 ± 0.51 |
| | 1600 | 2.81 | 2.6 ± 0.03 | 5.71 ± 0.15 | 0.14 ± 0.00 | 26.68 ± 0.44 |
| L3 (3rd low) | 1400 | 4.00 | 2.7 ± 0.06 | 6.02 ± 0.07 | 0.21 ± 0.01 | 22.48 ± 0.69 |
| | 1500 | 4.61 | 2.8 ± 0.00 | 6.37 ± 0.09 | 0.25 ± 0.00 | 20.37 ± 0.03 |
| | 1600 | 5.00 | 3.0 ± 0.03 | 6.72 ± 0.09 | 0.30 ± 0.00 | 17.39 ± 0.24 |
| L4 (4th low) | 1400 | 6.00 | 3.3 ± 0.06 | 7.00 ± 0.10 | 0.39 ± 0.01 | 14.88 ± 0.30 |
| | 1500 | 6.34 | 3.5 ± 0.06 | 7.39 ± 0.11 | 0.44 ± 0.01 | 13.03 ± 0.26 |
| | 1600 | 6.99 | 4.0 ± 0.12 | 7.80 ± 0.10 | 0.55 ± 0.01 | 10.58 ± 0.35 |
| | | | CD Values<br>Gear = 0.0953,<br>RPM = 0.0953<br>Gear x RPM = 0.165 | CD Values<br>Gear =0.114,<br>RPM = 0.114<br>Gear x RPM = 0.198 | CD Values<br>Gear = 0.0108,<br>RPM = 0.0108<br>Gear x RPM = 0.0187 | CD Values<br>Gear = 0.688,<br>RPM = 0.688<br>Gear x RPM = 1.192 |

**Field efficiency of Tractor operated Manure Spreader was taken as 20 %*

The effective field capacity of the manure spreader increased with increase in forward speed and engine rpm as shown in Figure 7. The fuel consumption also increased with increase in engine rpm and forward speed of tractor. As the forward speed of the tractor was increased by shifting to higher gear along with three engine rpm combinations the effective length (for emptying out trolley) over which the manure was spreaded also increased. Thus it lead to increase in

effective area over which the manure was applied resulting in decrease in manure application rate per unit area as shown in Table 3.

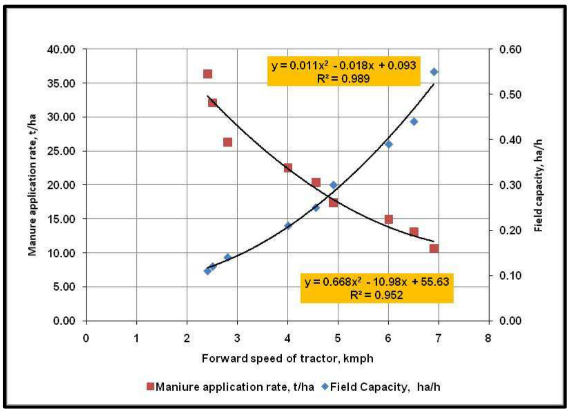


**Figure 6: Effect of Engine Rpm and Forward Speed on Manure Application Rate and Field Capacity**

The effect of engine rpm and gear individually and in combination was significant on ($p<0.05$) on manure application rate as shown in Table 3. As the engine rpm level and gear levels were increased the manure application rate decreased. Overall, increasing of engine rpm and forward speed of tractor combinedly resulted in increase in field capacity of machine, increase in fuel consumption but decrease in manure application rate per unit area (Figure 6).

The manure spreading was more uniform at 1600 engine rpm for all three gears as compared to 1400 and 1500 engine rpm. However, the machine spreaded manure more uniformly at 1600 engine rpm and 3$^{rd}$ low gear as compared to other combinations. The fuel consumption and forward speed at this combination were 6.72 l/h and 5.0 kmph respectively. Also the machine was operated at different locations in farmer fields and 80 ha area was covered as shown in Table 4.

**Table 4: Area Covered by Manure Spreader at Farmer's Field**

| S. No. | Area Covered | No. of Locations |
|---|---|---|
| 1 | 80 ha | 5 |

The area and production under different crops grown in India are shown in Table 5. The requirement for various cereals, pulses, fodder and vegetable crops sown in rabi and kharif season are shown in Table 6.

**Table 5: Area and Production of Various Crops Grown in India**

| Name of Crop | Area (Million Ha) 2012-13* | Production (Million Tones)2012-13* |
|---|---|---|
| Rice | 42.75 | 105.24 |
| Wheat | 30.00 | 93.50 |
| Coarse cereals (Bajra, Jowar, Maize, Ragi) | 24.76 | 40.04 |
| Pulses | 23.25 | 18.34 |
| Oilseeds | 26.48 | 3.09 |
| Sugarcane | 4.99 | 341.19 |
| cotton | 11.98 | 34.22 |
| Horticultural crops (Fruits and vegetables) | 23.4 | 268.80 |

**Annual Report 2013-14, Department of Agriculture and Cooperation, Ministry of Agriculture, Govt. of India*

**Table 6: Farm Yard Manure Requirement for Different Crops Grown in India**

| S. No. | Name of Crops | FYM Requirement*T.Ha$^{-1}$ |
|---|---|---|
| **A. Rabi Crops** | | |
| 1. | Wheat | 20-40 |
| 2. | Winter Maize | 20-25 |
| 3. | Sunflower | 25 |
| 4. | Berseem | 15 |
| **B. Kharif Crops** | | |
| 5. | Rice | 30-37.5 |
| 6. | Sugarcane | 20-25 |
| 7. | Sesame | 25 |
| 8. | Bajra | 25 |
| 9. | Napier Bajra Hybrid | 50 |
| 10. | Soyabean | 10 |
| **C. Vegetables** | | |
| 11. | Muskmelon | 25.0-37.5 |
| 12. | Watermelon | 20-25 |
| 13. | Sweet Potato | 25 |
| 14. | Summer Squash | 37.5 |
| 15. | Pumpkin | 20-25 |
| 16. | Brinjal | 25 |
| 17. | Root crops (carrot, radish and turnip) | 37.5 |
| 18. | Bottle gourd | 50-62.5 |
| 19. | Bitter gourd | 25-37.5 |
| 20. | Tomato | 12.5 |
| 21. | Chilli | 25-37.5 |
| 22. | Okra | 37.5-50 |
| 23. | Kharif and RabiOnion | 50 each |
| 24. | Garlic | 50 |
| 25. | Cauliflower | 100 |
| 26. | Broccoli | 100 |
| 27. | Chinese cabbage | 37.5-50 |
| 28. | Palak | 25 |
| 29. | Lettuce | 37.5 |
| 30. | Potato | 50 |
| 31. | Arum (*arvi)* | 25-37.5 |
| 32. | Turmeric | 25-30 |

** Package of practices for kharif crops of Punjab, Kharif 2013, PAU, Ludhiana, Package of practices for kharif crops of Punjab, Rabi 2013, PAU, Ludhiana, Package of practice for cultivation of vegetables,2013,PAU Ludhiana*

However, these requirements vary depending upon soil type, nutrient levels of soil and crop practices being used. The manure spreader can be operated as per required application rate by increasing or decreasing the swath width. In general manure requirement for major crops varies from 10-100 t/ha. The required manure application rate could be achieved by changing gear and engine rpm levels. Higher manure application rates could be achieved by increasing the overlapping area or width of overlapping.

The economics of tractor operated manure spreader and traditional method were compared. For economics calculations, an average application rate of 17.39 t/ha (corresponding to 3$^{rd}$ low gear and 1600 engine rpm) was selected. The machine was fully loaded (1.2 t), its loading time was noted for each replication, and spreading time was noted at

combination of 5.0 km/h and 1600 engine

rpm (for fully emptying out trolley). The size of normal trolley used by farmers in Punjab is 3.66m x 1.83 m x 0.91m. Its effective width is 1.83 m and its loading capacity varies between 1.50-2.00 tonnes (approx.) depending upon moisture content of the manure. Two people were required for loading and spreading manure from trolleys. The time of loading and spreading of manure in traditional method (for fully emptying out) was also taken. Keeping all these factors in consideration the economics of manure spreader was compared with traditional manual method and is shown in Table 7.

**Table 7: Economics of Tractor Operated Manure Spreader as Compared with Traditional Method**

| Particulars | Manure Spreader | Traditional Trolley Method | Tractor |
|---|---|---|---|
| New Cost, P (Rs.) | 5,00000 | 2,50,000 | 5,50000 |
| Salvage Value, S (10 % of P), Rs. | 50,000 | 25,000 | 55,000 |
| Life, L (Years) | 12 years | 12years | 10 years |
| Average Use/Year (h) | 700 | 600 | 1000 |
| **Annual Fixed Charges** | | | |
| Depreciation, Rs./yr (P-S/L) | 37,500 | 18,750 | 49,500 |
| Rate of interest, i (%) | 12 | 12 | 12 |
| Interest cost, Rs/yr = (P+S/2)*i | 33,000 | 16,500 | 36,300 |
| Taxes, Insurance and shelter Rs./yr, 2% of P | 10,000 | 5000 | 11,000 |
| Total fixed cost, Rs/year | 80,500 | 40,250 | 96,800 |
| **Total Fixed Cost, Rs/Hr** | **115** | **67** | **97** |
| **Variable Cost** | | | |
| Repair & maintenance (Rs./h) = 7% of P/Average use /year | 50 | 29 | 39 |
| Fuel required, l/h | 6.72 | 4 | ------ |
| Fuel cost, Rs/h (Fuel cons. X Rate) | 349 | 208 | ------ |
| Cost of lubricants, (Rs./h) = 20 % of fuel cost | 70 | 42 | |
| Labor cost, (Rs//h) | 30 | 30 | ---- |
| **Total Variable Cost, Rs./H** | **499** | **309** | **------** |
| **Total Costs** | | | |
| **Fixed + Variable (Rs./h)** | **614** | **376** | **136** |
| **Total Cost of Using Implement with Tractor (Rs./H)** | **750** | **512** | **----** |
| Avg. Capacity, tonne | 1.20 | 1.50 | |
| Application rate considered t/ha | 17.39 | 17.39 | ---- |
| No. of trolley required | 14.5 | 12 | ---- |
| Time required per trolley (including loading and spreading manure), h | 0.42 | 1.5 | ---- |
| **Total Time Required, h** | **6.09** | **18.00** | **----** |
| Total cost for this application rate, Rs. *(USD*)* | 4568 *($ 69.10)* | 9216 *($ 139.40)* | ---- |
| Saving in Time % | 66.17 % | ---- | ---- |
| Saving in cost % | 50.43 % | ---- | ---- |

**1USD = 66.11 Indian rupee*

## CONCLUSIONS

During field testing of tractor operated solid manure spreader, the swath width varied from 2.3-4.0 m and fuel consumption varied from 5.35-7.80 l/h. The machine effective field capacity varied from 0.11-0.55 ha/h and manure application rate varied from 10.58-36.37 t/ha. Variation in manure application rate was achieved by varying forward speed

and engine rpm. The average saving in time for spreading manure with tractor operated manure spreader was 66.17 % and average saving in cost was 50.43 % as compared to traditional method. Moreover, spreading of manure with manure spreader is finer and uniform as compared to traditional method. However manure spreaing was more uniform at 1600 engine rpm for three gear levels as compared to other engine rpm levels i.e. for 1400 and 1500. The tractor operated manure spreader ensures saving in time, cost as well uniform spreading as compared to traditional method. By using farm yard manure farmers can reduce the use of chemical based fertilizer and our precious resources such as soil and water can be saved from getting polluted. The farm yard manure spreader can be a boon for organic farming as it reduces the drudgery involved in traditional manure spreading operation. also provides a good employment opportunity for rural youth as this machine can be successfully run on custom hiring basis.

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